Introduction to extracting lateral motion from the dynamic speckle in Photon Doppler Velocimetry data

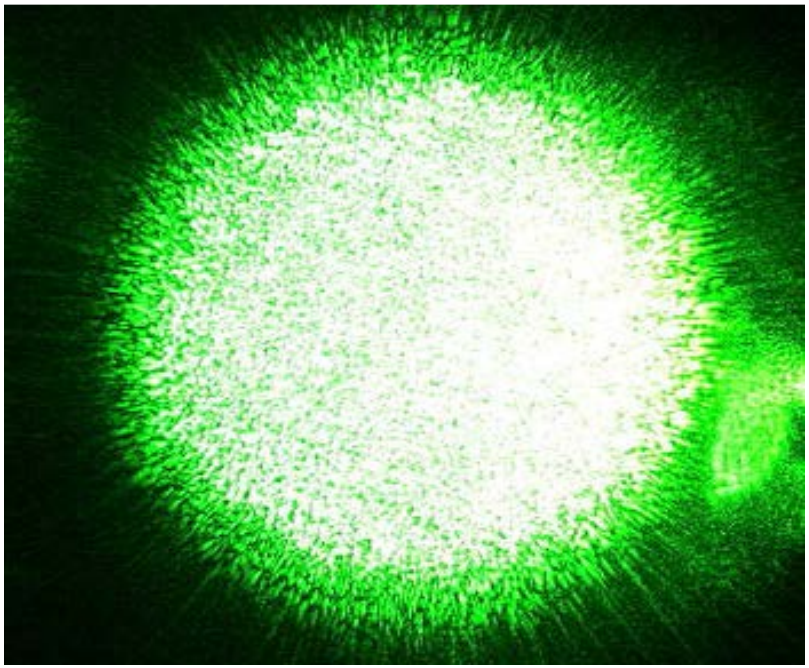

Image taken from Wikipedia article "Speckle"

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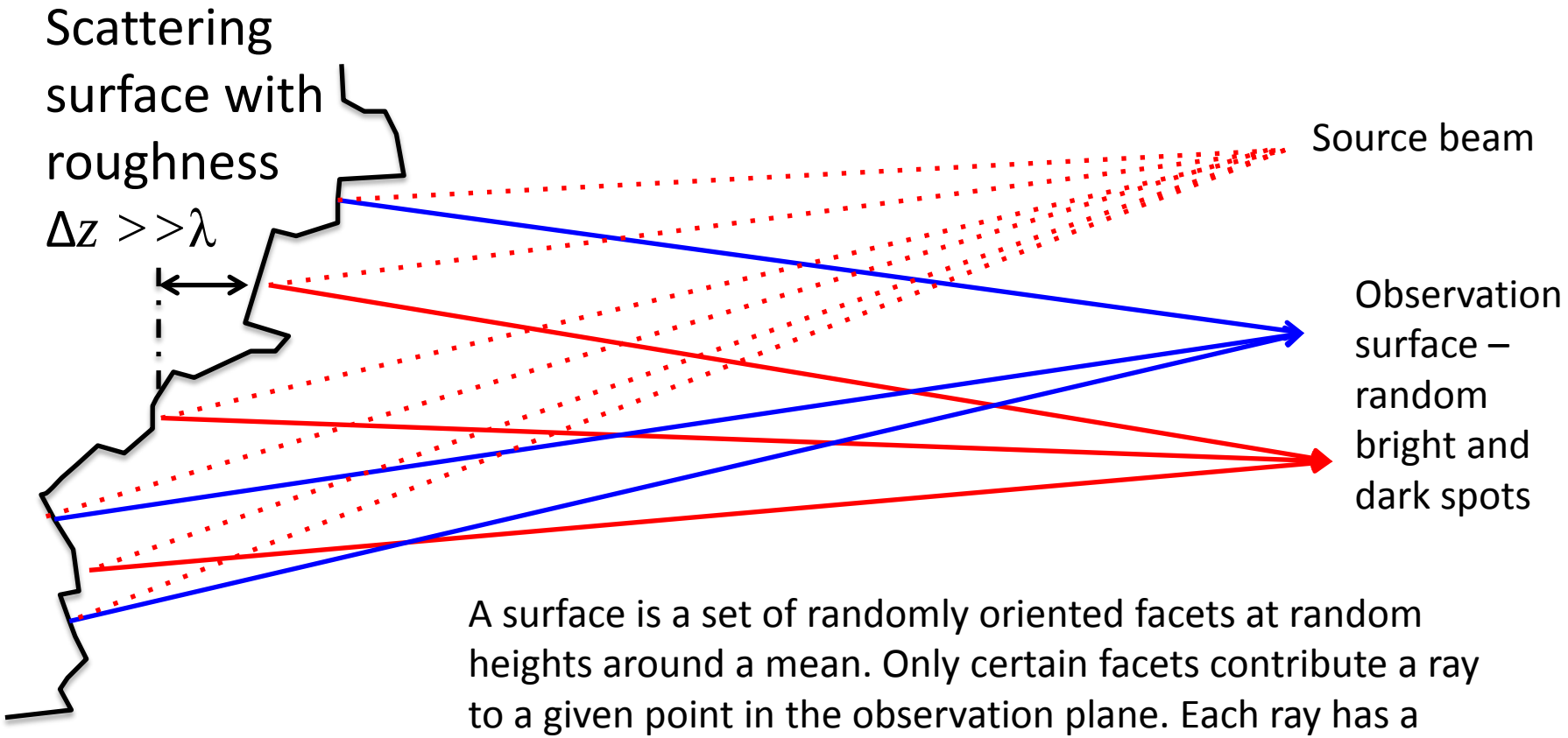
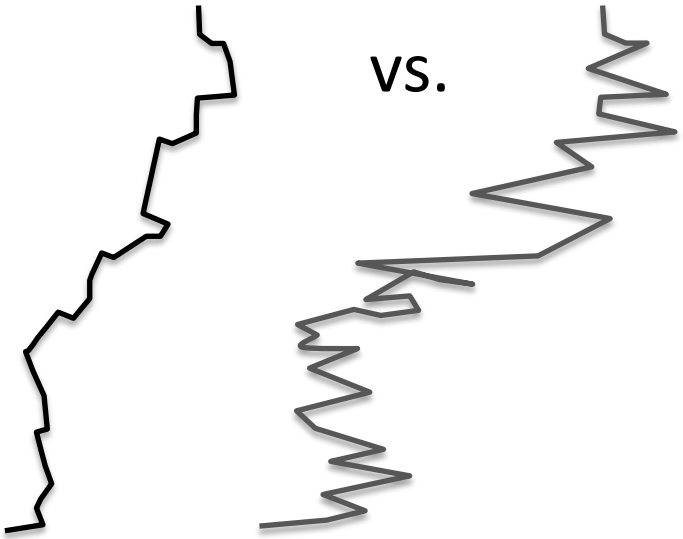
Speckle arises from the superposition of light from a collection of sources with random phase differences between them.



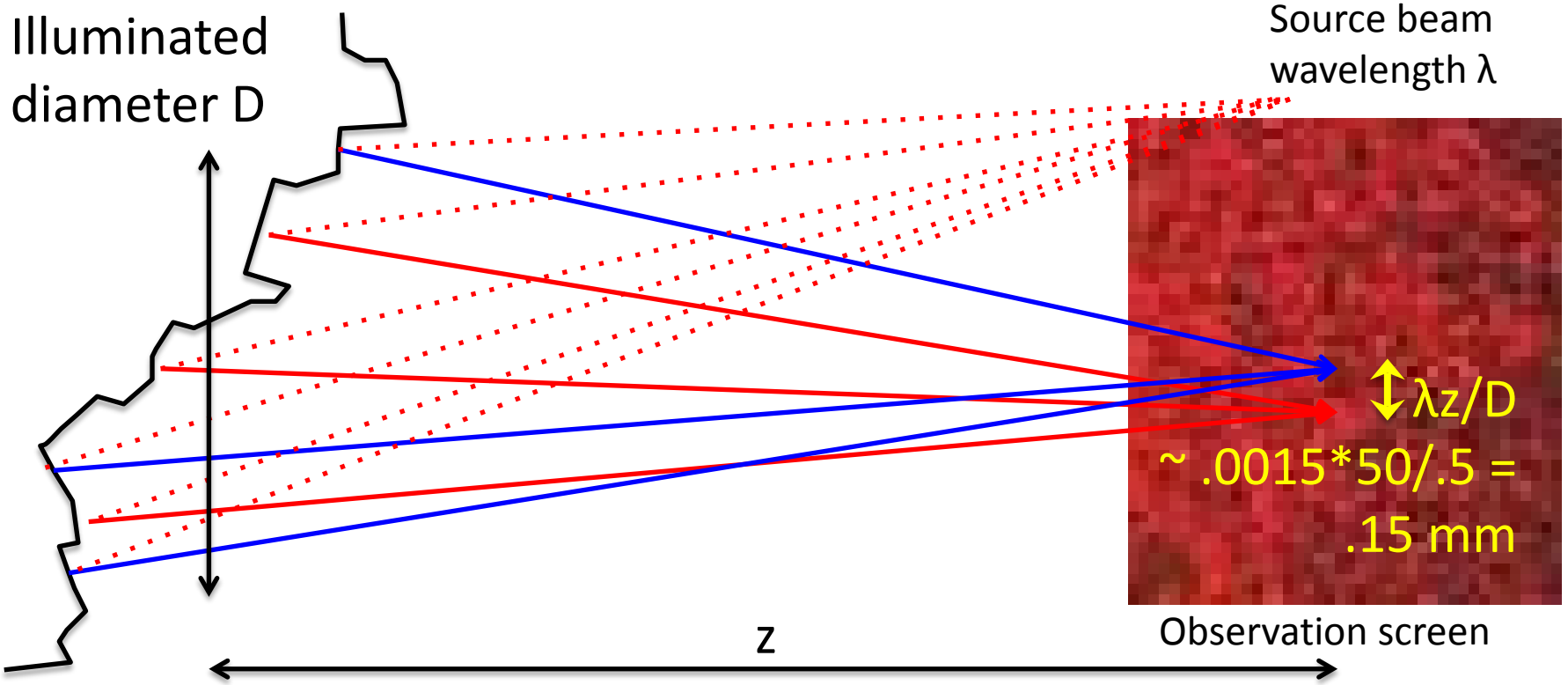
A surface is a set of randomly oriented facets at random heights around a mean. Only certain facets contribute a ray to a given point in the observation plane. Each ray has a random phase relation to each other ray. The result is a random set of bright and dark spots.

Once the surface roughness >> λ (1.5 μm) all surfaces look the same to speckle: a set of random phasors.



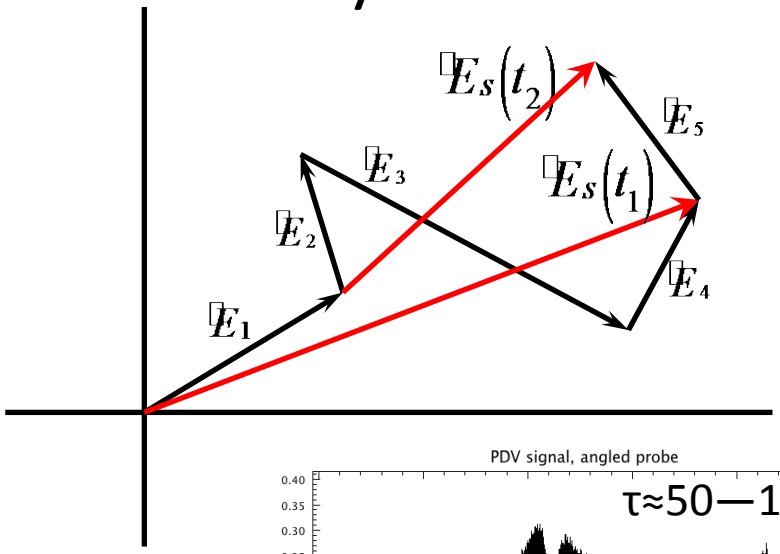
"Deep random phase screen:" The superposition is a random walk; a small number of large amplitude waves is the same as a large number of small amplitude waves. Beckmann & Spizzichino, *The scattering of electromagnetic waves from rough surfaces.*

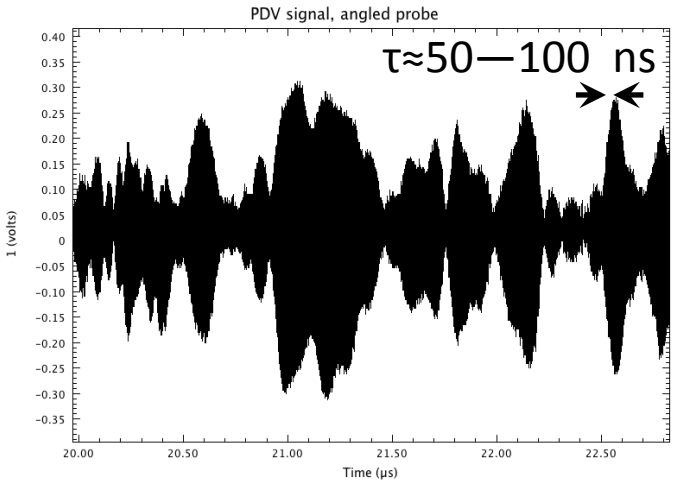
The set of facets that illuminate a given point on the observation surface changes gradually as we move along the observation surface…speckle has a characteristic size = λz/D ~ .15 mm at 1.5 μm, independent of roughness.*



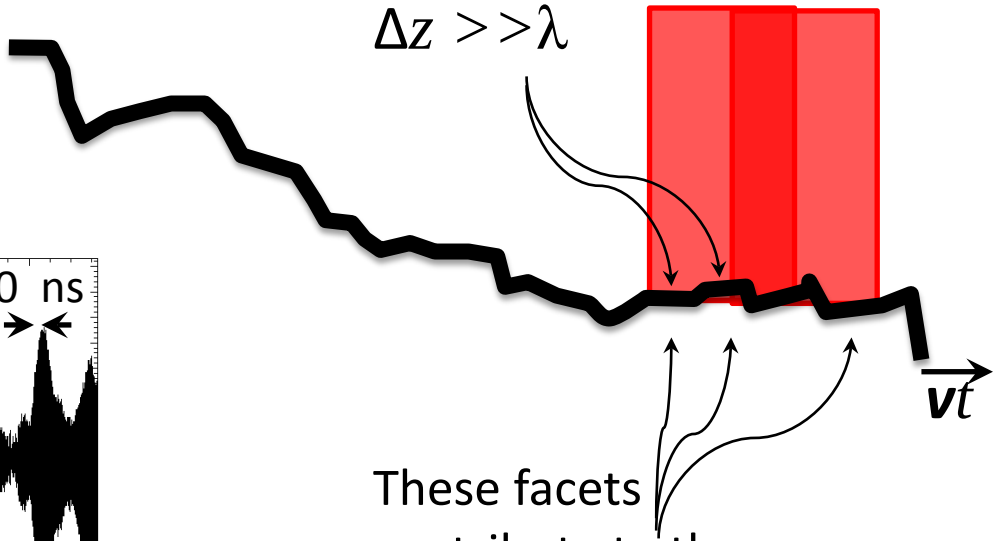
*Dainty C (Ed), *Laser Speckle and Related Phenomena*

The PDV probe collects a small area of a few speckles in the scattering field. As the target moves, the changing facets cause the speckle pattern to change within the collection area. Since the speckle have a characteristic size, the dynamics should be related to the speed.



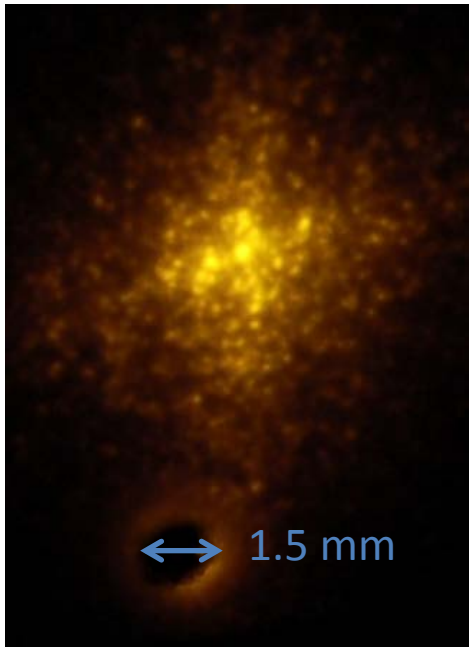


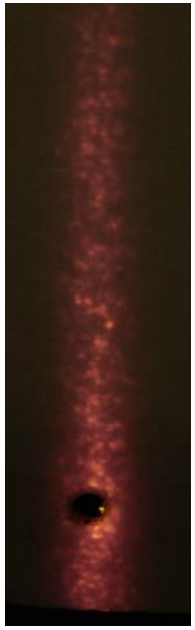
The probe beam at two different times

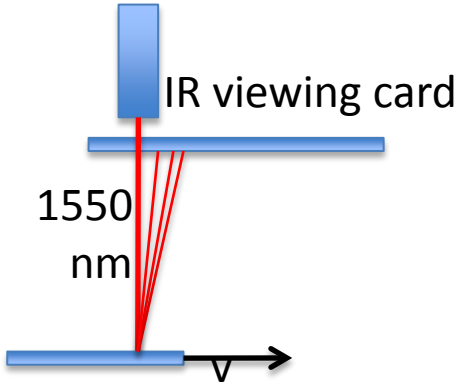


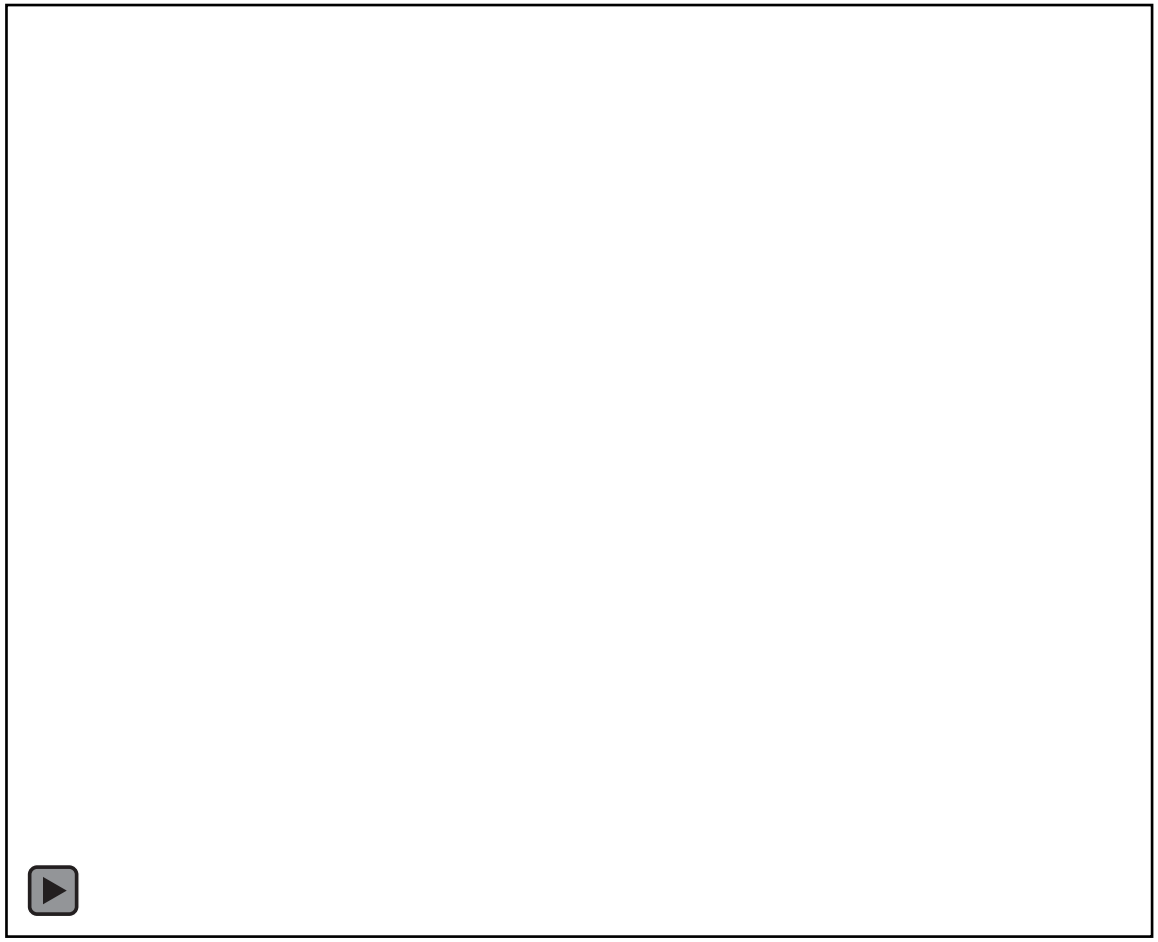
These facets contribute to the signal

1550 nm illumination of metal gives speckle ≈1/10 mm as calculated…movie shows an accelerating target.









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